CHAPTER 1

1.0 INTRODUCTION

1.1 Motivation

Spray drying is a well established method for converting liquid feed materials into a dry powder form (Anandharamakrishnan *et al.*, 2007) by using hot gas steam. The water content in the feed materials is rapidly vaporized from the droplets, leaving particles of dry solid which are separated from the gas stream. The particles produced are light and porous. Spray dryer are widely used in food industries, such as production of whey and milk powder, in healthcare and pharmaceutical products such as enzyme and vitamins (Masters, 1991) and also production of fertilizers, detergent soap and dyestuff. All these productions are produce from different types of spray dryer.

Gas flow pattern is one of primary factor that influence the quality of the product by spray dryer. The internal gas flow pattern directly influences the residence time each droplet or particle spends within the dryer, and the temperature of the gas which surrounds the particle during this period. These parameters affect the moisture content, size distribution, and porosity of the final product (Harvie *et al.*, 2001).

In recently year, to ensure the quality of the spray dryer production, there were a lot of experimental had been done. The quality of the product from spray dryer processes can be determine by using advanced method such as Laser Doppler Anemometer (LDA) and Phase Doppler Anemometer (PDA). However this measurement equipment still has their limitations. The LDA and PDA techniques were difficult and very expensive in large scale spray dryer. Alternatively, CFD can provide detail description on the multiphase flow in spray dryer which is certainly much cheaper to run compare to experiment. CFD modelling tools are increasingly used in the design, scale-up, optimization, and trouble-shooting of spray dryer (Anandharamakrishnan *et al.*, 2007).

1.2 Objective and scope

The aim of this study is to develop a modelling method for predicting single phase and multiphase hydrodynamics in spray dryer chamber to make possible the modelling spray drying via CFD. The first part of this work dealing with the modelling of single phase spray dryer were carried out to evaluate the performance of various turbulence models namely standard k-ε (SKE), RNG k-ε (RNG), Realizable k-ε (RKE), RSM and Detached Eddy Simulation (DES) and this study cover the axial and tangential velocity flow in a spray dryer at several positions. The second part involves the development method for multiphase flows which i.e. spray drying of maltodextrin. The Discrete phase model (DPM) was selected with energy balances equation to give the prediction of simultaneous heat and mass transfer during the drying process. Two different case study was performed as follow using FLUENT 6.3 CFD package.

Case A: Counter-current spray dryer simulation using the geometry and boundary conditions studied by Bayly *et al.* (2004).

Case B: Co-current spray dryer simulations using geometry and boundary conditions studied by Kieviet (1997).

1.3 Main contribution of this work

The Detached Eddy Simulation (DES) employed to solve a turbulence flow in a single and multiphase flows spray dryer in this work is relatively new and has not been previously applied to solve for a spray dryer. It is important to develop a method that can be employed by designers or practical engineers as an exploratory design and scale-up tools. To predict the performance of spray dryer accurately, must be able to model the flow pattern in spray dryer (Harvie *et al.*, 2001). In the past, modelling of gas flow pattern was limited comparison of turbulence models prediction on hydrodynamics of complex spray dryer design such as counter-current spray dryer tower. The previous CFD studies either under or over predicts the experimental data due to shortcomings of the turbulence model used.

Therefore, the Detached Eddy Simulation (DES) was employed to solve the turbulence model in single and multiphase in spray dryer in this work. Further detail about the DES is given in section 3.5.1. DES model is belonged to hybrid turbulence models, which blend Large Eddy Simulation (LES) away from the boundary layer and RANS near the wall. This marks a significant improvement in spray dryer modelling, which enable a direct comparison with LDA experimental data.

1.4 Thesis outline

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 provides applications and general features of the spray dryer. A general description on the flow characteristics in spray drying chamber and correlations to account for the flow phenomena are presented. This chapter also provides a brief discussion about the previous work related to advanced experimental techniques available for spray dryer, mentioning their applications and limitations for gas flow pattern analysis.

Chapter 3 will present the solution procedures about the spray dryer modelling dimension and set-up and also give a detail of the computational approach applied for spray dryer modelling of single and multiphase flows including the turbulence modelling, computational grid, and particle heat and mass transfer model for multiphase flow and solution procedures. The mathematical model used to account for turbulence flow of single and multiphase system is also described.